A STUDY OF THE FEASIBILITY OF USING ROADSIDE RADIO COMMUNICATIONS FOR TRAFFIC CONTROL AND DRIVER INFORMATION

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Chairman

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SUMMARY

The problem of roadside communication with a driver on a modern highway is becoming increasingly difficult. A new method of communication, employing a radio system developed by Delco Radio was tested in July and August, 1963, on the Kentucky Turnpike. This radio system, called Hy-Com, incorporates car-mounted receivers and roadside transmitter installations for communication between the roadside and the driver.

In making this study, data were used from a study being conducted by the Engineering Experiment Station, Georgia Institute of Technology. In this study random samples of vehicles were selected, half as a test group and half as a control group for each of three experiments in which the test group drivers received radio information on accidents and typical maintenance activities. In the route information experiment, no control group was used. Both test and control groups received similar information from the signs. Data on traffic flow were collected using time-lapse motion picture photography at locations just beyond the points of information reception. In addition, test vehicle operators were interviewed at the end of the 10-mile test section to determine their reaction to radio communication for traffic control and driver information.

Results of the experiments showed that radio communication is an effective device for controlling vehicle speed in hazardous areas as indicated by the significant differences in speeds of the test and control vehicles at the hazardous locations. The difference in the lateral placement distribution between the test and control vehicles immediately

prior to the hazardous areas was significantly different in some of the experiments. The route information given in one of the experiments was considered from the results of driver interviews to be quite helpful and a possible future use of the radio system. The interview data revealed that the motorists considered radio communication a very useful device and that it should be used in a variety of situations providing a variety of information. Driver acceptance for this system was indicated by the amount drivers were willing to pay for a radio receiver capable of receiving roadside communication. This receiver would be constructed as an integral part of the usual car radio and would operate if the car radio was on or off.

CHAPTER I

INTRODUCTION

Accompanying the highway engineers' accomplishments in freeway building and design is a distinct demand on the part of the people to make increasing use of these facilities. In order that this demand might be satisfied the freeways must exhibit certain characteristics to the driver, among them being safety, comfort, convenience and economy of time and money. With increasing volumes of traffic it is difficult to satisfy all of these characteristics. In particular, the task of communicating with the driver in order to inform him of directions, route information and roadway conditions becomes increasingly important. In order that a driver be given all the information he requires to safely and comfortably reach his destination, a reliable communications system must be used.

This system could conceivably be composed of a single subsystem, such as signs, but it seems more likely that a variety of subsystems will be developed and integrated so as to maximize the better attributes of each subsystem and ultimately result in a flexible, economical and reliable overall system.

Purpose

The purpose of the research project was to investigate the feasibility of a subsystem, namely, roadside radio communications to the driver, and evaluate it as a method of traffic control and driver information.

Also included in the research was an evaluation of the performance of the preliminary experiments in estimating the driver acceptability of the radio system. To accomplish these objectives a series of relatively simple but important experiments were designed and conducted on the Kentucky Toll Road from Shepherdsville to Louisville, Kentucky in July and August, 1963.

At the Shepherdsville toll plaza a State Trooper stopped every fourth vehicle and directed it into an area where test personnel determined whether or not the driver wanted to participate in the experiments. If the driver was willing to cooperate, he was designated as a test or a control vehicle and given information about the project. The test vehicles received a test radio. Both test and control vehicle operators were asked to drive over the ten mile test section and the test vehicle driver was asked to stop at the end for an interview. As the test vehicle operator drove over the test section, several messages were broadcast to him from roadside transmitters. A one thousand foot loop of wire beside each transmitter provided an induction field covering the two northbound lanes. As the test radio which was attached to the test vehicle passed through this field, its receiver was first activated and then the message received. Each driver of a test vehicle received four or five messages concerning actual roadway conditions. The experiments included an actual scene of an accident, maintenance activities, and route information.

As the test vehicle proceeded through the test section, its progress was recorded at three key locations by time-lapse motion picture photography. This information, in addition to the information secured from the interviews, allowed a careful and complete analysis to be made of the effect of the test radio and the driver acceptance of roadside radio communication.

Literature Research

Previous work in this field has been very limited, amounting to test installations of the same basic equipment used in the project. Delco Radio Division of General Motors Corporation has used test installations of this equipment in a few areas. At Flint, Michigan a driver-training field served as an experimental setup (5), (10). Here, however, no triggering device was used as all vehicles operated inside the information loop. Communication could then be continuous. This was clearly a special case, not usually feasible for highway adaption. Another installation was on the New York Throughway, where radio was used to give tourist information. However, no attempt was made to scientifically evaluate the equipment as a link in the comprehensive highway communications system.

CHAPTER II

DATA COLLECTION

Study Site

Several conditions were required in the selection of a test site. The test site had to be a controlled access facility in order that once the driver was given a test radio, he could not leave the turnpike before he came to the interview area where the test radio could be recovered. Also essential was that the site offer good locations for time-lapse movie camera placement. Traffic volume had to be such that one could continue to draw a systematic sample all day without either being flooded with vehicles or not having enough vehicles to obtain reliable data. Proximity to Kokomo, Indiana was also important when considering equipment maintenance by Delco personnel. A very important consideration was the willingness of the particular highway department to cooperate in the experiments. The full cooperation of the Kentucky Highway Department was assured for all phases of the test work in Kentucky.

Several toll facilities were considered, including the Sunshine State Parkway and the Ohio Turnpike. However, because of the above considerations, the Kentucky Toll Road was selected.

The study area as shown in Figures 1 and 2 was located on Interstate 65, Kentucky Toll Road, between the Shepherdsville, Kentucky Toll plaza and the Fern Valley Exit, just south of Louisville, Kentucky. The Kentucky Toll Road in the study area is a divided four-lane facility with 12 foot concrete lanes. The right hand shoulders are ten feet wide and

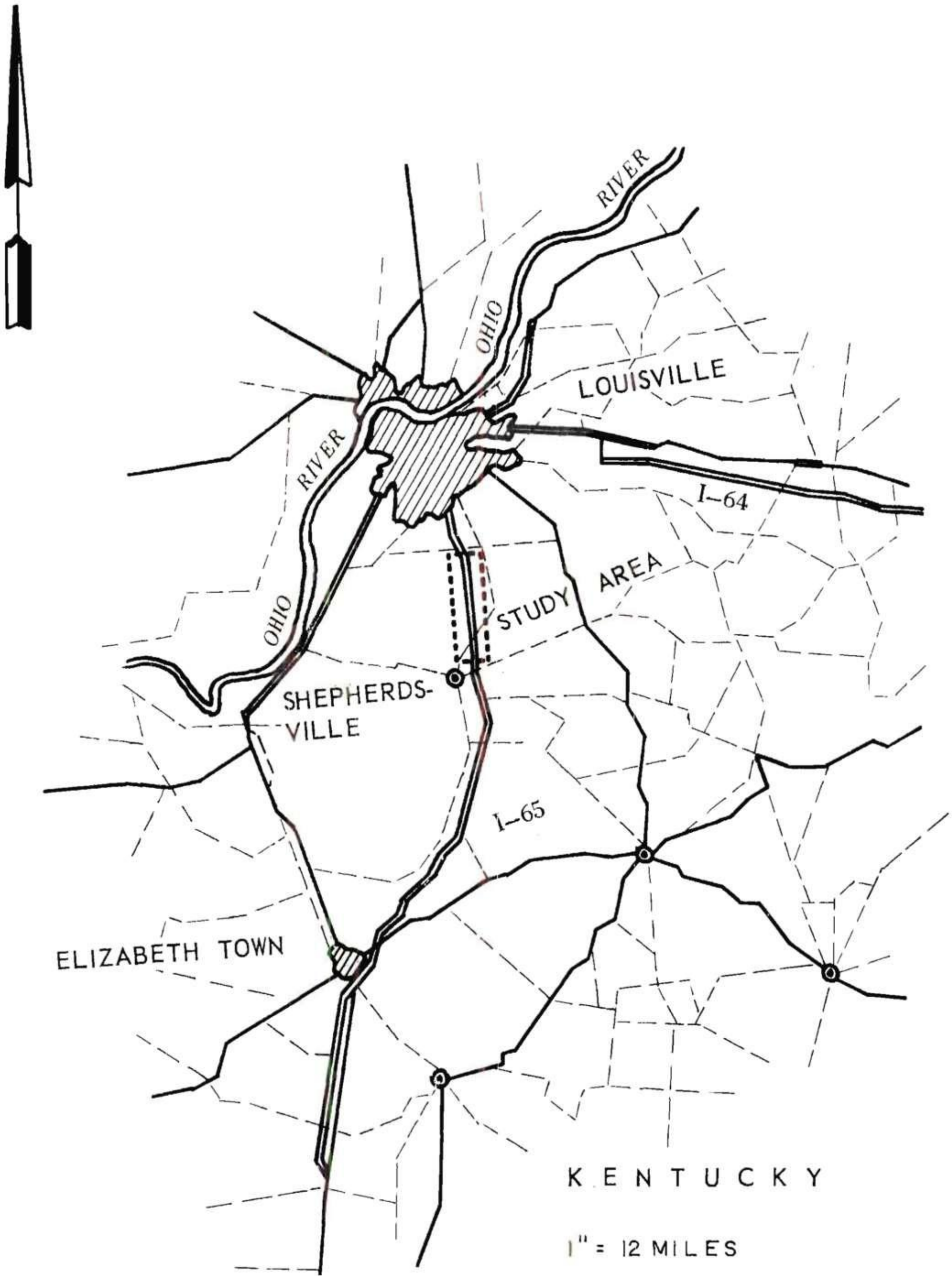


Figure 1. Location of Study Area.

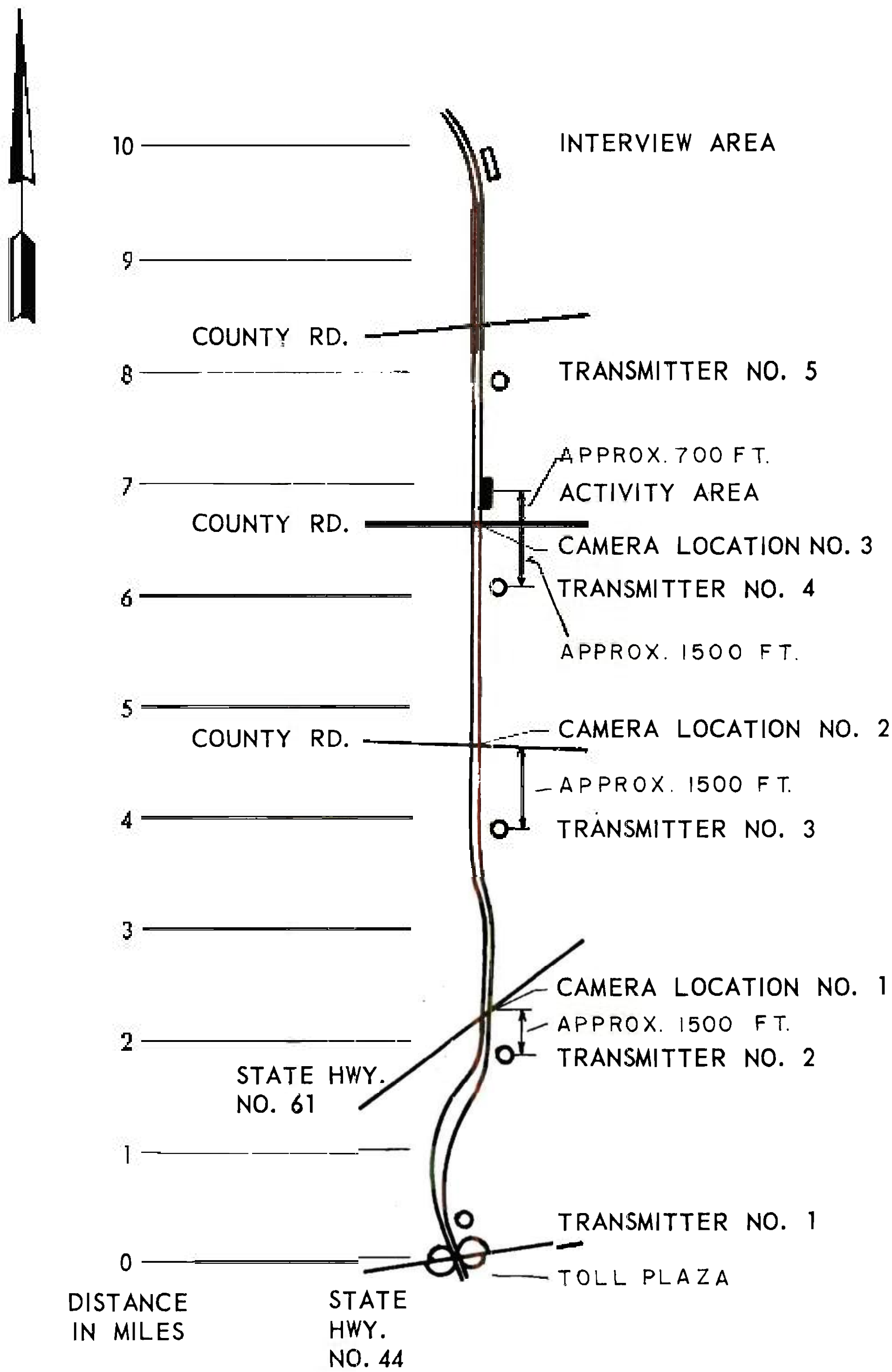


Figure 2. Study Area.

are paved with asphalt. The inside shoulder is approximately four feet wide and is also paved with asphalt. The median averages 16 feet in width and is of turf-type construction, raised approximately one foot. The horizontal and vertical alignment are consistent with the 70 miles per hour speed limit.

The ten mile test section of the Kentucky Toll Road had an average annual daily traffic of approximately 8,000 vehicles and a truck composition of approximately 20 per cent.

The experiments were conducted only when the pavement was dry and no rain was impending. All the experiments were conducted on weekdays between eight in the morning and five in the afternoon.

Equipment and Instrumentation

The radio equipment used was Delco Radio Hy-Com which is a system designed to provide communications from the roadside to the driver. The system consists of a car mounted receiver and a roadside transmitter installation.

The receiver system has two components, a receiver and a speaker. The receiving equipment as shown in Figure 3, is encased in a fiberglas and plastic case. On the bottom of the case are three circular magnets covered with phenolic discs. The receiver is mounted on the rear deck lid of a typical automobile and the rubber-coated safety hook placed in the crack between the trunk lid and the body of the automobile. The magnets and safety hook provided a secure method of attaching the receiver for most automobiles.

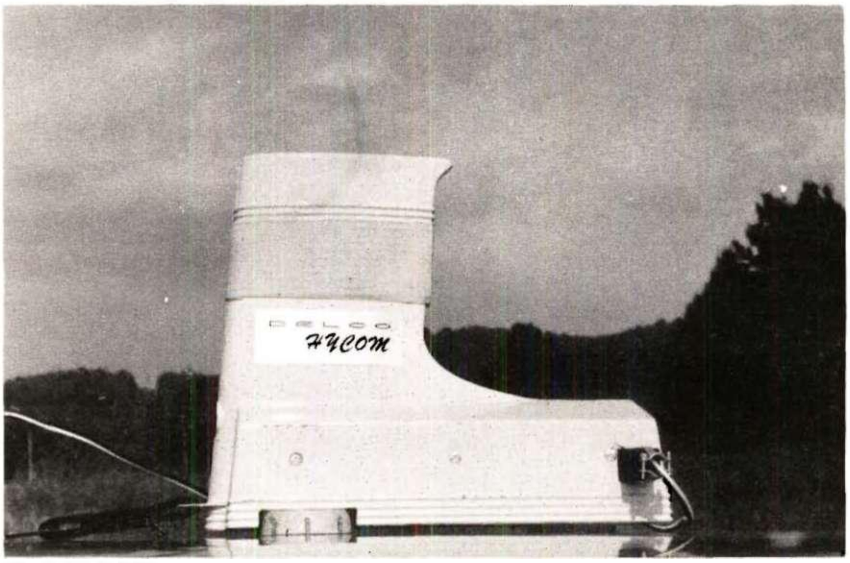


Figure 3. Radio Receiver Unit.

The receiving unit is powered by four 1-1/2 volt penlight batteries which provide for approximately 100 hours of continuous operation. An interconnecting cable from the receiver housing to the speaker permits the speaker to be located on the interior of the automobile. A spring clip on the rear of the speaker housing enables the speaker to be mounted on the sunvisor or other body trim.

The transmitting system consists of a transmitter cabinet, message repeater, controller, a trigger and information transmitter, as well as two loop antennae which are laid on the shoulder. A photograph of the transmitter equipment is shown in Figure 4. The transmitter cabinet can be installed at any required point along the side of a highway. The transmitter uses two 12-volt storage batteries for a power supply.

The transmitter system is a single sideband, suppressed carrier, one-way communication link. Audio information to be transmitted is recorded on a magnetic drum in the repeater. The repeater records messages of any duration up to ten seconds and will automatically repeat them.

A handset, located in the transmitter cabinet, serves as a microphone to permit recording and as a receiver to allow verification of proper recorder operation. A message which the driver is intended to hear is recorded on the repeater drum. At the end of the message, the repeater will reset itself and the message will be repeated. In the transmitter the message is amplitude modulated with a 12.1 KC carrier. Suppression filters then remove the carrier and the lower sidebands and deliver the upper sidebands to the power output stage which energizes a loop antenna. The loop antenna, establishes an inductive field

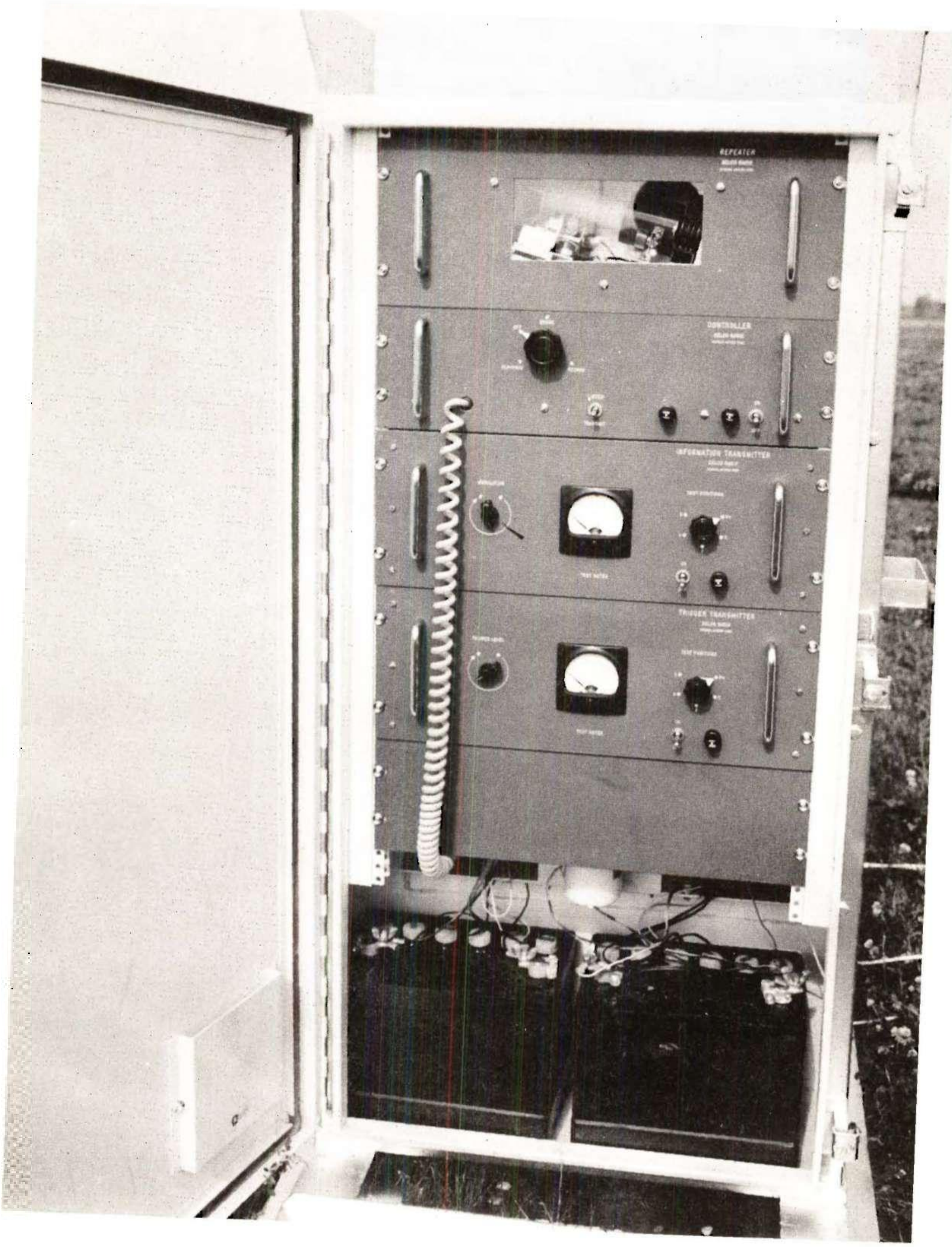


Figure 4. Inside View of Transmitter Cabinet.

which can be sensed by the receiver antenna as it passes the loop. To avoid confusion by having a southbound drive receiving a message intended for a northbound motorist, an additional trigger feature has been incorporated into the system. This feature consists of a 12.1 KC trigger transmitter and its associated trigger antenna. The trigger antenna is a loop of plastic-coated nineteen strand copper wire. When the induction field of the trigger transmitter is sensed by the receiver antenna, a trigger circuit in the receiver is activated which energizes the audio stages of the receiver. A time delay is designed into the system to hold the audio section in the "on" position to permit the automobile to pass the trigger loop and to reach the information loop. As the receiver enters the information loop, it senses the information signal and provides an audible message to the driver. With this system, a southbound driver would pass the information loop before he would pass the trigger loop. His receiver would be off and no audible message would be heard. It was found in the experiments that there was a certain amount of mechanical and electrical noise associated with the transmitter operation.

The information loop used in the experiments was 1,000 feet long and consisted of a loop of plastic-coated wire laid just off the shoulder of the turnpike. A distance of five feet separated the legs of the loop.

The trigger loop, made of similar wire, had seven turns of the wire in the loop with a similar separation. However, the trigger antenna loop was only about 25 feet long. The trigger loop was laid just off the shoulder and was located prior to the transmitter while the information loop was located after the transmitter. A sketch of the layout of the antennae is shown in Figure 5.

During the conduct of experiments time-lapse motion picture cameras were used to collect information concerning the traffic characteristics. Three cameras were used and each exposed approximately four 100-foot rolls of film during one day's operation. The camera used for collecting this data was a Bolex 16 mm movie camera driven by a Bodine 110 volt AC synchronous motor at a rate of 100 frames per minute. The film capacity of the camera was 100 feet and, therefore, a total of forty minutes of filming time was available. The time interval between each frame was six tenths of one second. The time error for 36 minutes of film was less than ±1 per cent. Because an accurate time interval was very important, a synchronous motor was used to drive the camera. However, because of the remoteness of the camera locations, no convenient source of AC electrical power was available. Therefore power was provided by employing a 12-volt heavy duty battery and a 75-watt continuous, 100-watt intermittent vibrator-type convertor. The convertor and battery were enclosed in a special box which accompanied each camera.

The shutter speed used was one-fifteenth of a second. Although this was a comparatively slow speed, the blurring that resulted on the film by the moving vehicles (40 to 70 miles per hour) was not sufficient to cause any significant errors in the analysis.

On the drive shaft from the motor to the camera, a safety device was installed to prevent the camera from being damaged in the event the film jammed. The drive shaft was made in two parts and a rubber clutch was used to connect the shafts. As color coding of vehicles was necessary Kodachrome II color film was used.

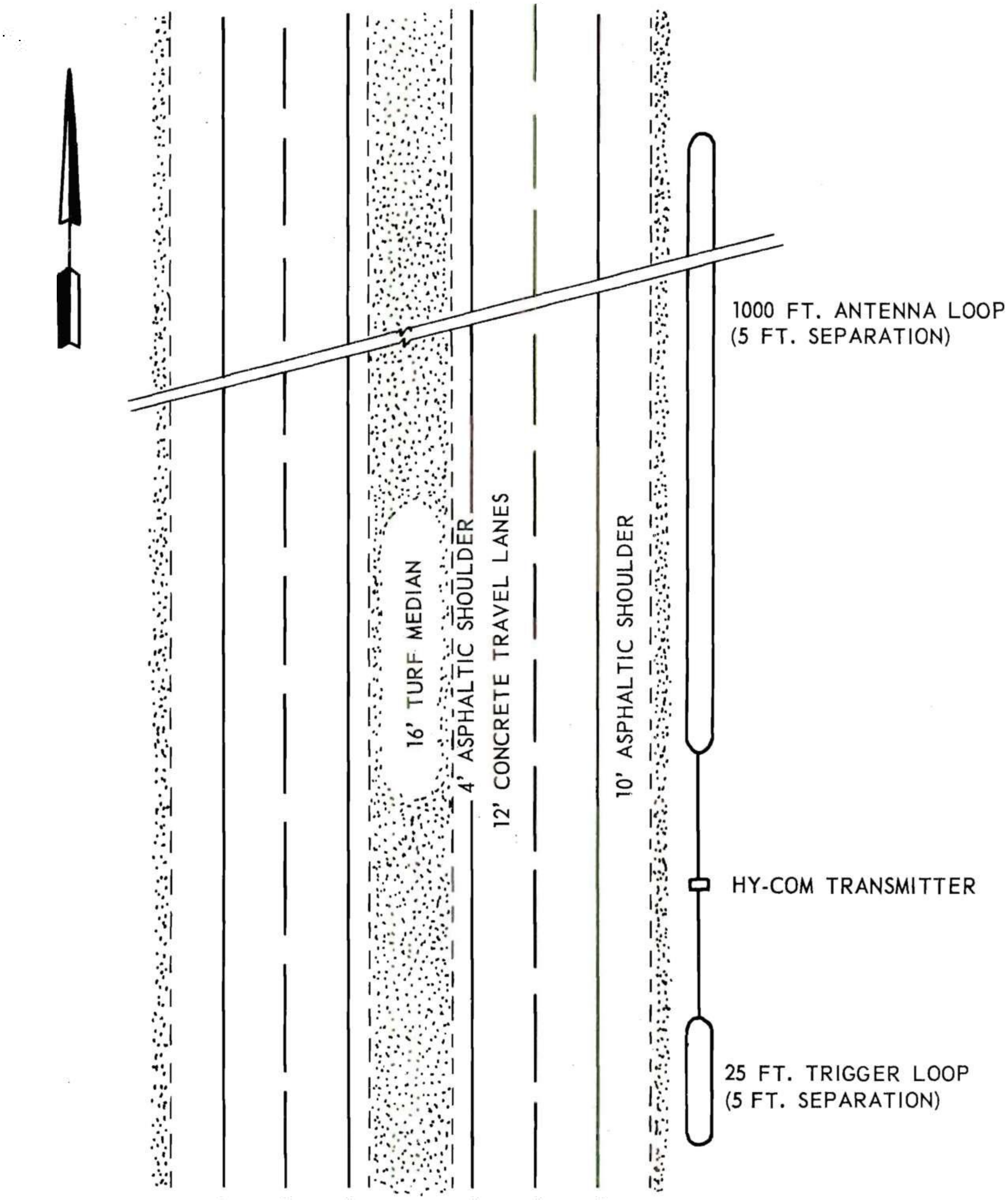


Figure 5. Typical Transmitter & Loop Installation.

In the actual filming, the film was exposed in nine-minute intervals. Each day was divided into nine-minute intervals and before each experiment, a random selection of these nine-minute intervals was made to obtain the intervals when the cameras would operate. Camera number two started two minutes after camera number one, and camera number three two minutes after camera number two. Thus, it was theoretically possible to follow a vehicle through all three camera locations.

Before any photography was taken, a grid system was painted on the shoulders of the pavement. The grid was painted at 40 foot intervals for a distance of 200 feet, perpendicular to the center line of the highway at all locations. Figure 6 shows a typical camera location and grid layout.

Procedure of Study

The experiments conducted in Kentucky were primarily designed to evaluate the feasibility of radio communications as a method of traffic control and to provide driver information. These preliminary experiments were also designed to familiarize the project personnel with the equipment, its limitations, potentials and operating characteristics.

Psychological factors were considered in the design of the experiments. The behavior of the persons directly involved in the experiment was considered to differ from that of non-participating persons. Because of this problem a control group of drivers was established. This control group would receive essentially the same information about the project as the test vehicles, and yet not be given a radio receiver.

The selection of test and control vehicles was made on the basis of systematic sampling with every other selected vehicle designated as

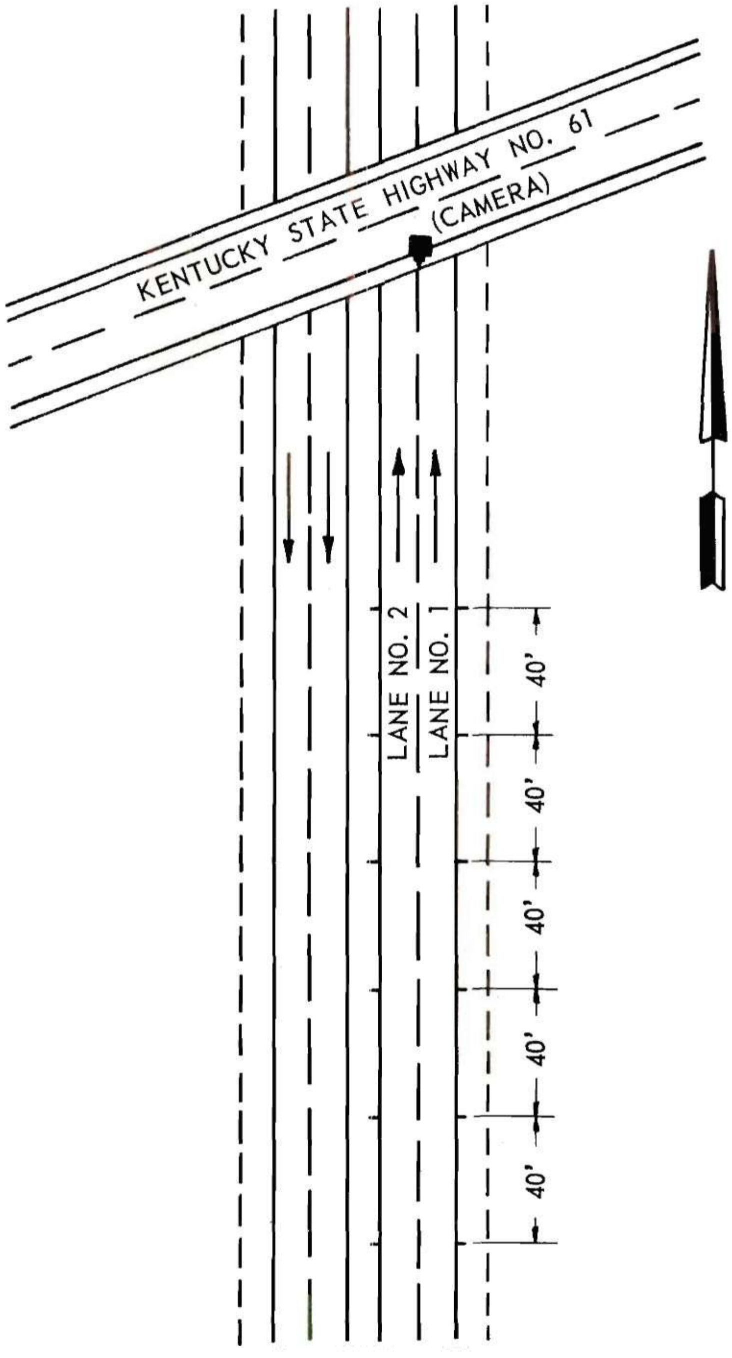


Figure 6. Typical Camera and Grid Layout.

a control vehicle or a test vehicle. The selection of the vehicles was done by a Kentucky State Police Trooper who directed every fourth vehicle passing through the Shepherdsville Toll Plaza to pull into the inside lane where the vehicle was processed. Only the northbound drivers were sampled. A sketch of the toll plaza area is shown in Figure 7.

Each selected vehicle was approached by one of the project personnel. The driver was given a short explanation of what the project was attempting to do and then asked for his cooperation. If the driver of the vehicle elected not to cooperate, the project personnel simply asked for a refusal reason and excused him, whereupon another vehicle other than the every fourth vehicle normally selected was asked to participate in the experiment. Whether the vehicle was designated as a control vehicle or test vehicle, the driver was given approximately the same information. A copy of the information that was given to each vehicle, test or control, may be seen in the Appendix.

If a vehicle designated as a control vehicle accepted the invitation to participate, he was identified by placing a bumper sticker on his front bumper. The bumper sticker was chartreuse in color so that it would be quite noticeable in the time-lapse movie photography. The placement of the sticker identified the driver as being male or female. A sticker placed on the right side indicated a female driver, on the left side, a male driver. The driver of the control vehicle was then given a brochure explaining the project to read when time was available.

If a vehicle was a test vehicle, the vehicle was similarly coded with bright red bumper stickers, positioned so as to identify the sex of the driver. In addition to this identification, the vehicle was also

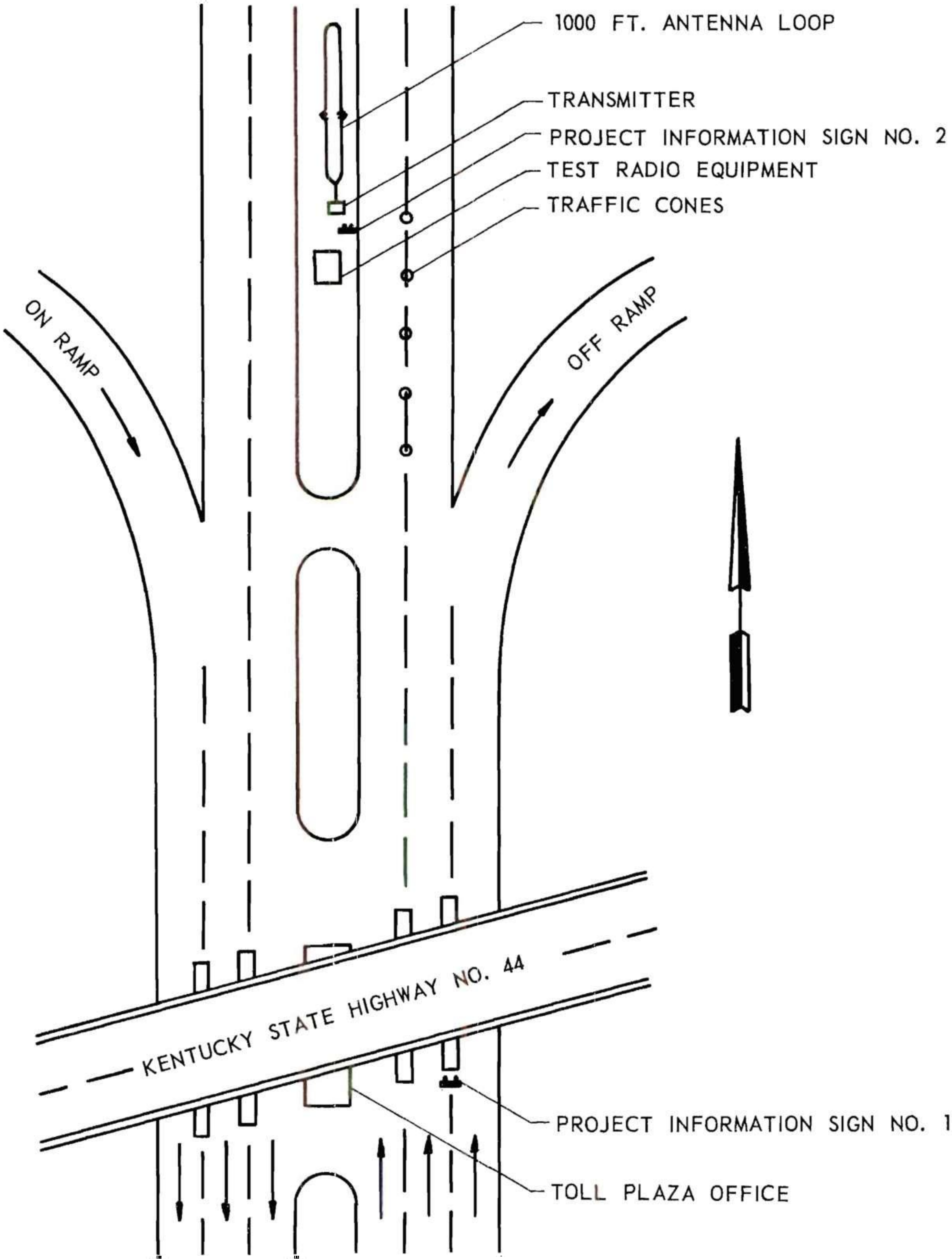


Figure 7. Schematic Layout of Shepherdsville Toll Plaza Area on Interstate 65.

outfitted with a test radio unit. On most passenger vehicles the radio receiver was attached to the rear deck lid and the speaker to the sun-visor. Some were taped to the top of buses and trucks, some were set on the gas tanks or steps of trucks, while on sport cars the receivers were put wherever room was found.

The drivers of the test vehicles that did cooperate and were given a receiver unit had their license numbers recorded to facilitate recovery of the unit if they did not stop at the interview area where the receiver would ordinarily be removed. The drivers that did not cooperate were asked to indicate their refusal reasons and be excused.

The motorist, once outfitted with the radio, drove through the test section where he was given several messages and stopped for an interview at the end of test section. There he was given the information brochure.

At the well signed and marked interview area, the radio unit and identifying sticker were removed and the driver was allowed to continue after the interview was completed. The interview took from three to five minutes.

The questions were designed to evaluate the driver's acceptance of this form of communication based upon his very short exposure to it. Other uses were suggested and the drivers were asked their opinion on usefulness. Several questions were designed to measure the effectiveness of the radio communications. The choice of alternatives within the questions was randomized from interview to interview so as not to create any position bias in the replies.

The recording sheet for the interview was also coded to facilitate data treatment. A copy of the questionnaire and the coding form may be found in Appendix A.

Four experiments were performed each dealing with a different road situation. Each experiment was replicated twice, once on each of two randomly selected days. The main theme of each experiment is listed below.

Experiment 1	Accident scene
Experiment 2	Maintenance (grass cutting on median)
Experiment 3	Maintenance (patching on shoulder)
Experiment 4	Route information

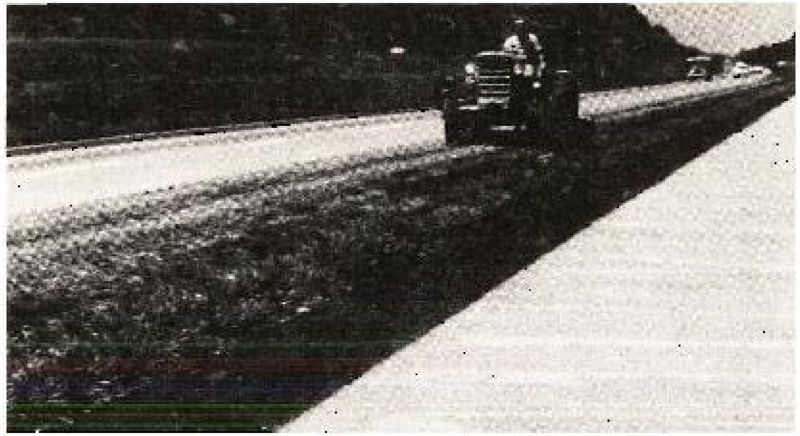
Experiment I

Experiment I, the accident scene, was conducted on two days, July 23, 1963 and August 1, 1963. To simulate actual conditions a tow truck, a wrecked vehicle, and a State Police cruiser were positioned in lane two (median lane) of the toll road in the experiment activity area. Only in this experiment was traffic narrowed to one lane. A State Police officer was available to direct traffic through the area should any congestion develop. The only other warning devices used were the red flashers on the police vehicle and the wrecker. Figure 8a shows a photograph of the accident experiment.

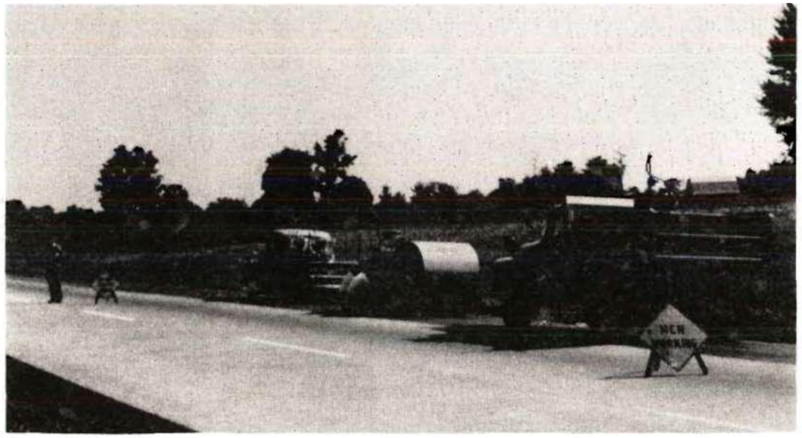
The messages given to the test vehicles were as follows:

Transmitter No. 1	"This is Hy-Com Radio Communications. Several messages describing actual roadway conditions will be given in the next 10 miles." Repeated once in ten seconds on recording drum.
Transmitter No. 2	Not used.

(a) Accident Scene – Experiment 1



(b) Mowing Scene – Experiment 2



(c) Patching Scene – Experiment 3

Figure 8. Scenes at Activity Area.

Transmitter No. 3 "Accident ahead two miles" ...repeated four times in ten seconds on recording drum.

Transmitter No. 4 "Accident ahead, use right lane" ...repeated three times in ten seconds on recording drum.

Transmitter No. 5 "Drop off test radio in one mile" ...repeated four times in ten seconds on recording drum.

Cameras were located at bridges number 1, 2 and 3 and each exposed several rolls of film in nine-minute increments randomly spaced throughout the day.

Experiment II

Experiment II was conducted on two days, July 24 and July 26, 1963. In this experiment a normal maintenance activity took place. In this case, grass cutting was chosen and the State Highway Department had a tractor mower working on the median. No lane blockage was necessary in the activity area. A picture of a typical operation may be seen in Figure 8b. No warning signs were employed. The message given to the test vehicles were as follows:

Transmitter No. 1 "Messages concerning actual roadway conditions will be given in the next ten miles" ...repeated twice in ten seconds on recording drum.

Transmitter No. 2 Not used.

Transmitter No. 3 "Grass cutting two miles ahead" ...repeated four times in ten seconds on recording drum.

Transmitter No. 4 "Grass cutting, slow to 40" ...repeated three times in ten seconds on recording drum.

Transmitter No. 5 "Drop off test radio in one mile" ...repeated three times in ten seconds.

Experiment III

Experiment III was conducted on July 25 and on July 30, 1963. In this test a typical maintenance activity, "skin patching" the shoulder, was the activity simulated in the activity area. The Kentucky State Highway Department supplied several trucks and the necessary personnel to realistically execute the work. A picture of the patching operation on one of the test days is seen in Figure 8c. The patching operation required that half lane one be blocked in the activity area. For the duration of the test, the working force employed a flagman and typical maintenance signing. The signing and flagman were visible to the approaching drivers while they were still in the grid at camera location three.

The messages given to the test vehicles were as follows:

Transmitter No. 1	"Messages describing actual roadway conditions will be given in the next ten miles" ...repeated twice in ten seconds on recording drum.
Transmitter No. 2	Not used.
Transmitter No. 3	"Men working two miles ahead" ...repeated four times in ten seconds on recording drum.
Transmitter No. 4	"Men working, slow to 40" ...repeated three times in ten seconds on recording drum.
Transmitter No. 5	"Drop off test radio in one mile" ...repeated three times in ten seconds on recording drum.

Cameras were located in the same locations as in other experiments.

Experiment IV

This experiment was conducted on July 31 and August 2, 1963. In contrast with the other experiments, this experiment provided only route information to the test vehicles. No roadway activity was described and consequently there was no reason for test vehicles to perform differently from the control vehicles in the traffic stream. For this reason no film data was taken and consequently, it was not necessary to select control vehicles as no film analysis would be performed. The messages given to the test vehicles were as follows:

Transmitter No. 1 — "Messages concerning route information conditions will be given in the next ten miles" ...repeated twice in ten seconds on recording drum.

Transmitter No. 2 — "Louisville, home of Kentucky Derby, 15 miles" ... repeated three times in ten seconds on recording drum.

Transmitter No. 3 — "Cincinnati, 135 miles on US-42" ...repeated three times in ten seconds on recording drum.

Transmitter No. 4 — "Indianapolis 125 miles on I-65" ...repeated three times in ten seconds on recording drum.

Transmitter No. 5 — "Drop off test radio in one mile" ...repeated three times in ten seconds on recording drum.

Film Analysis

The film obtained was projected through a Kodak Analysist motion picture projector. This projector allowed a frame by frame analysis of each roll of film. The analysis was performed by projecting the film onto a screen upon which a grid was superimposed. This superimposed grid was made to correctly fit the grid that was painted on the pavement shoulders and within the camera field of view. Using this technique it was possible to analyze the film for vehicle speeds, volume and lane use.

The analysis of the film was conducted as follows. As a vehicle approached the grid and entered into the camera field of view, it was identified as a test, control or other vehicle. If it was a test or a control vehicle, the film was run backward to allow the analysts to observe the behavior of the vehicle as it traversed the section of the highway from the transmitter to the grid. Any passing maneuvers or lane changes were noted. Next, the vehicle was advanced until it crossed the first grid line. The grid used in this analysis may be seen in Figure 9. Its position was carefully noted and the vehicle again advanced until it reached a position immediately before going out of the grid section. The distance it travelled in the grid was then accurately determined. The time it took for the vehicle to traverse that section of the grid, (0.60 seconds for each frame) was determined. Also noted was the lateral placement of the right hand edge of the vehicle as it crossed a grid line in the foreground that was used as a reference line. The total width of the pavement at the reference line was divided into three foot sections and the frequency of observations noted for each section. A more detailed discussion of the methods used to make analysis of time lapse photography can be found in Reference 3.

Also available from the film analysis was the vehicle type and the sex of the driver was determined noticing the placement of the colored bumper stickers.

Interview Analysis

Each driver that was involved in the experiment as a test vehicle was asked to stop at the interview area and have the test radio and bumper sticker removed from his car and subject themselves to a short

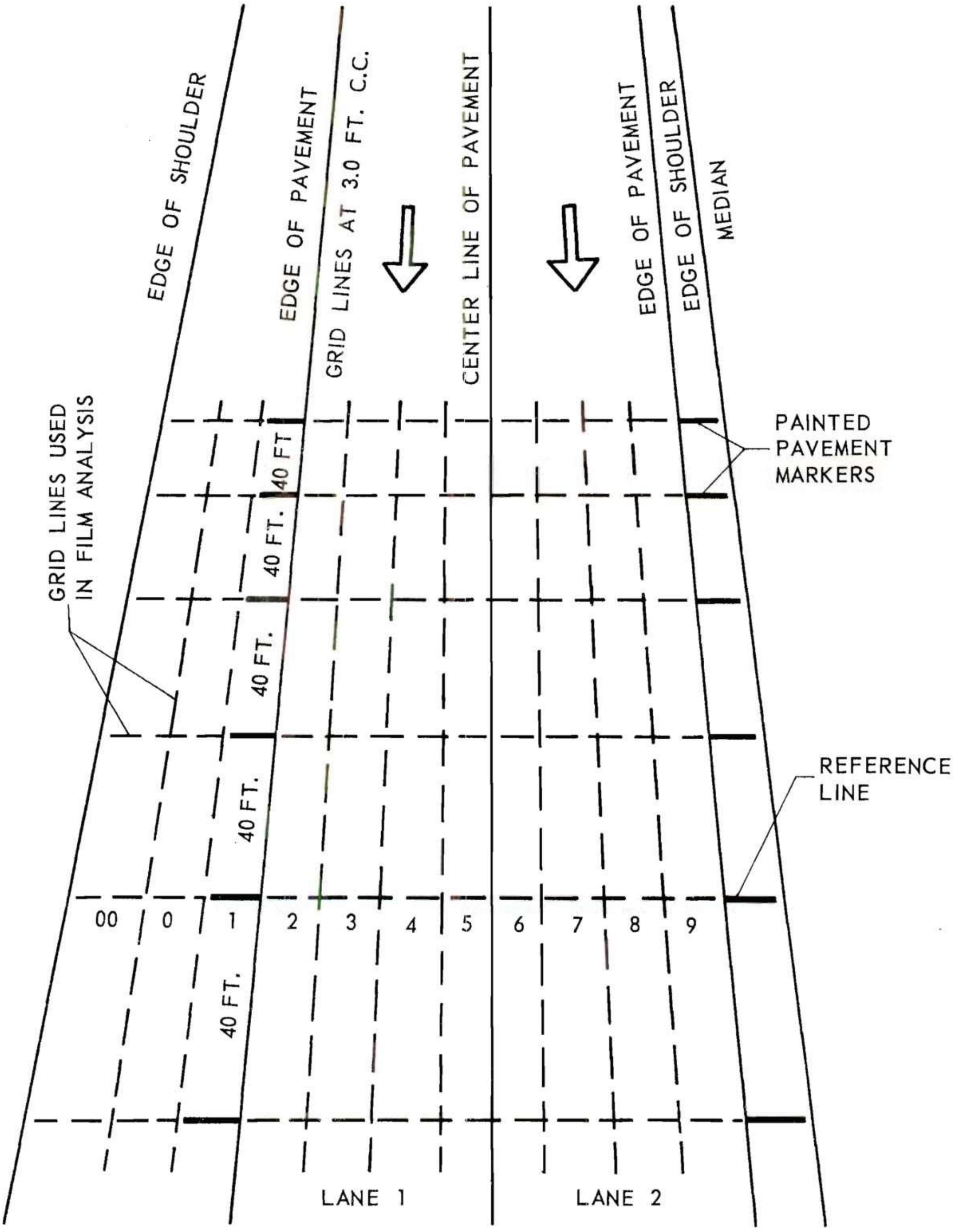


Figure 9. Perspective Sketch Showing Grid Superimposed on Highway Test Section.

interview. Each interviewer was quite familiar with the interviewing procedure and conducted the interview in a fashion so as to minimize any bias that may develop in the experiment.

The data obtained from the interviews was treated as subjective data based on the very short exposure time of the drivers involved. These data were presented in the form of percentages or in an histogram as shown in Figure 12.

CHAPTER III

ANALYSIS OF DATA

Computation of Results

In the original design of the experiment consideration was given to the fact that equal representation of all elements would not be obtained. This meant that when analyzing data for differences between male and female drivers, local and non-local drivers, or passenger vehicles and other classes of vehicles, there would not be an equal number of observations for each group. Thus in the collection and subsequent classification of the data it was expected that some comparative analyses would not be possible. This problem existed in the film analysis of the results of experiments one, two, and three. For example, on one day only four female drivers of test vehicles appeared in the film at camera location one, whereas thirty-nine male drivers were observed. However, because such large variations could not be foreseen, extensive data classification was justified.

The data collected in the film analysis were carefully considered in view of the above considerations. These limitations made it necessary to pool over vehicle type and sex of the driver in the statistical computations. Calculations were then made for each of experiments one, two, and three that indicated the average speed of the test vehicles and control vehicles at the three camera locations, for each of the two days that the experiment was conducted. Even when pooling over the sex of the driver and the vehicle type, each pooled speed value did not represent an equal number of observations. This condition violated the orthogonality requirements of a factorial design and made it difficult to independently estimate the main effects and interactions without entanglement. However, because each pooled speed value represented at least forty observations, this infraction of theory was not considered serious.

When the tabulation of the data was completed, the data were examined using the analysis of variance methods. Because all main effects were fixed, the three factor interaction term would logically be used as the error term against which the initial tests would be made. The error term had only two degrees of freedom. This situation rendered the "F" tests rather ineffective and so a new error term was calculated. The new error term, the "within cell mean error variance," was calculated as follows. An unbiased estimate of the variance of each cell in the final tabulation of the data was calculated. Then, a pooled variance was calculated. Finally, the pooled variance was divided by the average sample size for that experiment, and this gave a new error term which had a greater number of degrees of freedom (in excess of five hundred).

The pooled variance for each of the three experiments when checked with Snedecor's "F" test, permitted the acceptance of the hypothesis that the test and control vehicles all came from the same type of population.

Analysis of Variance

Analysis of variance is a very powerful tool in the field of experimental statistics. One must remember however that the analysis of variance is only a convenient way of detecting and separating the effects of the factors and the process of interpreting the results is by no means automatic. Using the analysis of variance the conclusions drawn can be accompanied by probability statements as to the correctness of the inferences.

A mathematical model was formulated, using the independent and dependent variables associated with each experiment. The quantitative physical characteristic (dependent variable) of interest was:

1. Speed

The independent variables of interest were:

1. Day of experiment
2. Test or control vehicle
3. Location of camera.

The model developed for the analysis of variance on the dependent variable, speed, was as follows:

$$Y_{ijk} = \mu + P_i + D_j + V_k + PD_{ij} + PV_{ik} + DV_{ik} + DV_{jk} + PDV_{ijk}$$

This model states that an individual observation of speed at the i^{th} location, on the j^{th} day and of k^{th} vehicle is composed of an expected value "μ" plus the sum of any main effects and interaction effects due to the independent variables. The factors for experiments one, two and three are presented in Table 1. Analysis of variance was not used for analysis of data in experiment four.

A level of significance was established to aid in reaching conclusions about significant differences of the independent variables of interest in a particular model. These levels of significance refer to the probabilities that the existence of real differences among the levels of the independent variable are concluded when only differences caused by chance fluctuations in the data exist.

In performing the analysis of variance on the speed data, the 5, 10, and 20 per cent levels were used. The 5 per cent level was used only to illustrate that some of the factors and interactions were very significant. The 20 per cent level was used only if a factor was not significant at the 10 per cent level in an attempt to find the level where the factor is said to be significant, the 10 per cent significance level is implied. This connotes the following meaning. The probability that a factor is said to be significant, when in reality it is not significant, is 0.10.

Table 1. Primary Variables for Analysis of Variance of Speed on Kentucky Turnpike

Factor	Abbreviation	Subscript	No. of Levels	Fixed or Random Factor
Location of cameras	P	i	3	Fixed
Day of test	D	j	2	Fixed
Type of Vehicle	V	k	2	Fixed

CHAPTER IV

DISCUSSION OF RESULTS

Multiple Range Tests

The analysis of variance showed which of the interactions and main effects were significantly different but did not show which level of the main effects caused the differences. Using Duncan's Multiple Range and Multiple F tests (4) it was possible to determine which level of the main effects caused the differences to exist. Duncan's tests were applied to the variables after they were placed in rank order, lowest to highest, and those variables not significantly different were underlined. The factors underlined together may be taken in any order since they are not significantly different.

Analysis of Variance for Speeds

Experiment One

The results of the analysis of variance for experiment one may be seen in Table 2 and indicate that of the main effects, the location of the camera and the type of vehicle were significant. In the interactions, the camera location-vehicle and the camera location-day were significant. The latter interaction remains unexplained as every attempt was made to properly replicate the experiment.

Table 3 shows the rank order and significant differences of the vehicle speeds at different camera locations. Studying Table 3, it becomes evident that the speeds of the test and control vehicles are not

Table 2. Analysis of Variance for Speed on the Kentucky Turnpike - All Drivers, All Vehicle Classes Experiment 1 - Accident

	Levels of Significance		
Source of Variance	5%	10%	20%
1. Location of camera	Significant	Significant	Significant
2. Day	Non-Significant	Non-Significant	Significant
3. Vehicle Type	Significant	Significant	Significant
4. Location-Day	Significant	Significant	Significant
5. Day-Vehicle	Non-Significant	Non-Significant	Significant
6. Location-Vehicle	Significant	Significant	Significant
7. Location-Day-Vehicle	Non-Significant	Non-Significant	Non-Significant

Table 3. Rank Order of Vehicle Mean Speeds at Camera Locations for Experiment One[1]

Vehicle Type	Highest	Highest	Highest
Test Vehicles	Location 1	Location 2	Location 3
Control Vehicles	Location 2	Location 1	Location 3

[1]There are no significant differences in speeds of vehicles between those positions underlined.

significantly different at camera locations one and two. This is indicated by the underscoring of camera location one and two. There is, however, a significant difference in the speeds of the test and control vehicles between three and the other locations.

Table 4 presents the rank order and significant differences between the test and control vehicles observed at the different camera locations. Studying the table indicates that there are significant differences between the speeds of the test and control vehicles observed at camera locations two and three, but not at location one. Therefore, up to the first camera location the presence of the test radio did not affect the normal operating speed of the test vehicle operator. By the time the test vehicle operator reached camera location two, he had received a message informing him of an accident two miles ahead. At this point his speed was significantly different from that of the control vehicle operator who heard no message. At camera location three the difference was again significant as seen in Table 4. Prior to this camera location, only the test vehicle operators received the message, "Accident ahead, use right lane."

Table 4. Rank Order of Test and Control Vehicle Speeds at Different Camera Locations[1]

Location of Camera	Highest	Lowest
Location One	Control	Test
Location Two	Control	Test
Location Three	Control	Test

[1]There are no significant differences in speeds of the vehicles underlined at those positions.

Figure 10 shows the average speeds of test and control vehicles at the various camera locations for each experiment. The bars represent the speed of the test and control groups at particular camera locations. The

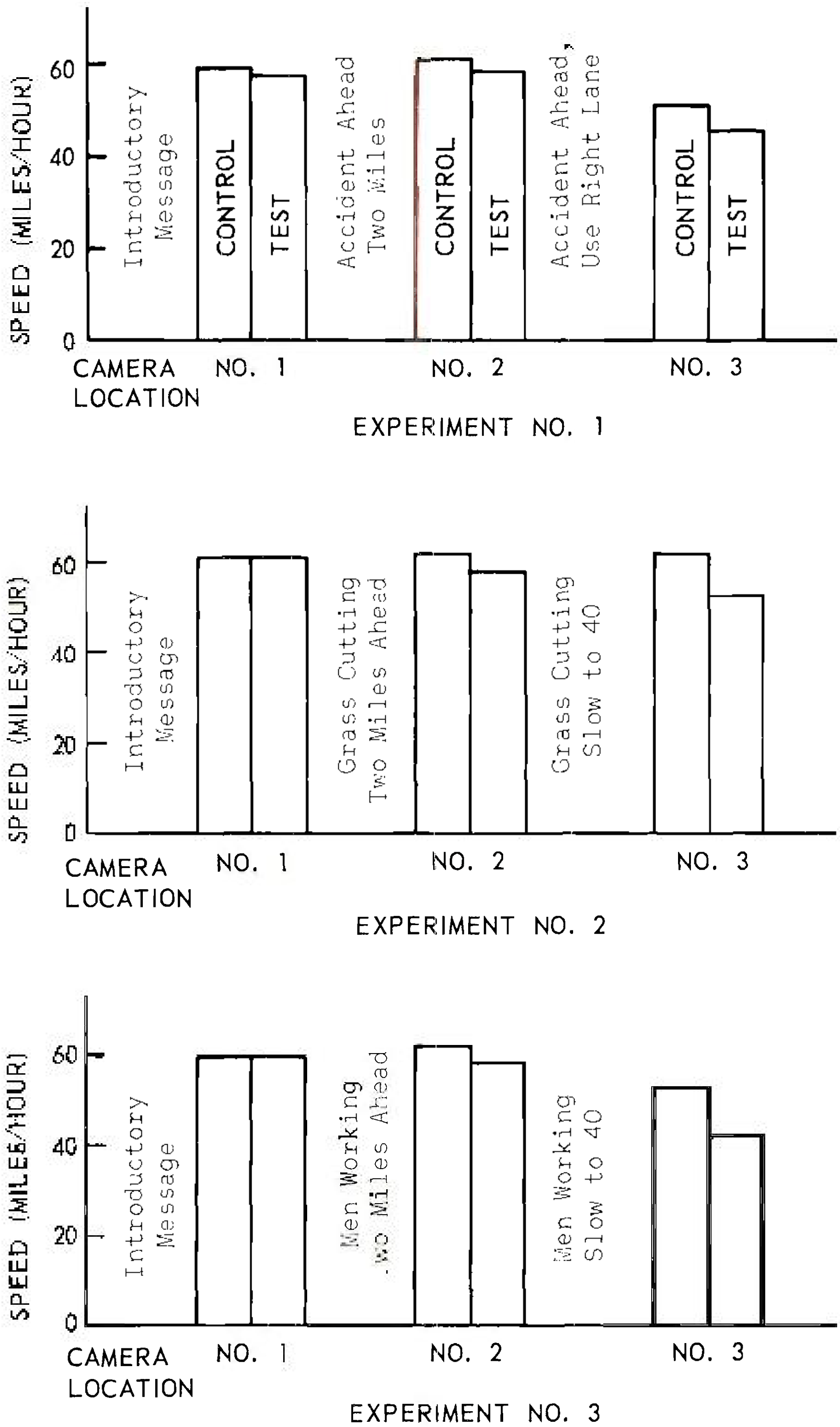


Figure 10. Average Speeds of Test and Control Vehicles (Averaged over 2 days).

message inserted between each set of bars was the message received by the test vehicles just before they reached the camera locations where the vehicle speeds were measured. The familiarization message was given at the toll plaza, about two and one-half miles before the first camera location.

Experiment Two

In Table 5 are presented the results of the analysis of variance for experiment two. The results indicate that the main effects, location of camera and vehicle type are significant even at the five per cent level. The interaction of these two main effects is also very significant.

Table 6 shows the rank order and significant differences of the test and control vehicles with respect to the different camera locations.

Table 5. Analysis of Variance for Speed on the Kentucky Turnpike - All Drivers, All Vehicle Classes Experiment 2 - Mowing

Source of Variance	Levels of Significance		
	5%	10%	20%
1. Location of Camera	Significant	Significant	Significant
2. Day	Non-Significant	Non-Significant	Non-Significant
3. Vehicle Type	Significant	Significant	Significant
4. Location-Day	Non-Significant	Non-Significant	Non-Significant
5. Day-Vehicle	Non-Significant	Non-Significant	Non-Significant
6. Location-Vehicle	Significant	Significant	Significant
7. Location-Day-Vehicle	Non-Significant	Non-Significant	Non-Significant

Table 6. Rank Order of Vehicle Mean Speed at Camera Locations for Experiment Two[1]

Vehicle Type	Highest	2nd Highest	Lowest
Test	Location 1	Location 2	Location 3
Control	Location 2	Location 3	Location 1

[1]There are no significant differences in speeds for vehicles between those positions underlined.

Upon an examination of Table 6 it is quite evident that the control vehicle speed was not significantly different at any of the camera locations. The test vehicle speed at camera location three is different from the test vehicle speed at the other two camera locations.

Table 7 shows the rank order and significant differences of test and control vehicle speeds observed at the three camera locations. It is evident that there exists no significant differences at camera location one. However, at camera locations two and three, there is a significant difference in speeds. The significant differences in speeds between the test and control vehicles can be attributed to the messages received by the test vehicle operators prior to camera locations one and two. These messages were respectively; "Grass cutting, two miles ahead," and "Grass cutting, slow to 40."

Figure 10 shows the average speed for the test and control vehicles.

The results of the analysis of variance for experiment three are presented in Table 8. The results indicate that only the main effects location of the camera and vehicle type and their interaction were significant. These effects were significant even at the five per cent level.

Table 7. Rank Order of Test and Control Vehicle Speeds at Different Camera Locations[1]

Location of Camera	Highest	Lowest
Location One	Test	Control
Location Two	Control	Test
Location Three	Control	Test

[1]There are no significant differences in speeds of vehicles underlined at positions indicated.

Table 8. Analysis of Variance for Speed on the Kentucky Turnpike - All Drivers, All Vehicle Classes Experiment 3 - Patching

	Levels of Significance		
Source of Variance	5%	10%	20%
1. Location of Camera	Significant	Significant	Significant
2. Day	Non-Significant	Non-Significant	Non-Significant
3. Vehicle Type	Significant	Significant	Significant
4. Location-Day	Non-Significant	Non-Significant	Non-Significant
5. Day-Vehicle	Non-Significant	Non-Significant	Non-Significant
6. Location-Vehicle	Significant	Significant	Significant
7. Location-Day-Vehicle	Non-Significant	Non-Significant	Non-Significant

Table 9 shows the rank order and significant differences of the test and control vehicles with respect to the different camera locations. Examination of Table 9 reveals that significant differences exist between

Table 9. Rank Order of Vehicle Mean Speed at Camera Locations for Experiment Three[1]

Vehicle Type	Highest	2nd Highest	Lowest
Test	Location 1	Location 2	Location 3
Control	Location 2	Location 1	Location 3

[1]There are no significant differences in speeds of vehicles between those locations underlined.

location three and the other two locations, with respect to the speed of the test vehicle. The same is true for the control vehicles.

Table 10 shows the rank order and significant differences of test and control vehicle speeds observed at the three camera locations. Only at location one are there no significant differences between test and control vehicle speeds. The presence of the test radio did not affect

Table 10. Rank Order of Test and Control Vehicle Mean Speed at Different Camera Locations[1]

Location of Camera	Highest	Lowest
Location One	Control	Test
Location Two	Control	Test
Location Three	Control	Test

[1]There are no significant differences in speeds of vehicles underlined at locations indicated.

the speed of the test vehicles so as to make it significantly different from the control vehicles. However, the messages received by the test vehicle operators prior to camera locations two and three did contribute to the significant difference in speed between the test and control vehicles at these last two camera locations. The messages were, "Accident ahead, two miles" and "Accident ahead, slow to 40," in that order. Figure 10 shows the average speed for the test and control vehicles for experiment three.

Lateral Placement of Vehicles

General

In addition to the speed data secured from the analysis of the films, information was also obtained concerning the lateral placement of the test and control vehicles at the three camera locations. To gather this information, the grid used in the speed analysis was modified slightly. Lines were drawn on the grid at three foot intervals parallel to the center line of the pavement. A typical grid for analysis of both speed and lateral placement is shown in Figure 9. As the vehicles approached in the direction indicated on the figure, they were classified as to test or control vehicles, vehicle type, i.e., passenger, station wagon, etc., and male or female driver. Their speed was then measured and the position of their right front tire recorded as being in section 00 through to 9 at the reference line. These data were collected for every test and control vehicle occurring in the films for the first three experiments.

These data were then analyzed using statistical techniques for significant differences in the test and control vehicle lateral placement distribution. Based upon amount of data collected and the distribution of observations in the various sections, 00, 1, ...9, a contingency test was used to analyze the data collected concerning the lateral placement of the vehicles in lane one in experiments one and two, and in lane two in experiment three. In lane two in experiments one and two, there were too few observations of vehicles to permit a statistical evaluation of their distribution at the reference line. The same is true for the third camera location in experiment three, except that lane one had the deficit of observations.

Experiment One

In Experiment number one there was a simulated accident in lane two in the activity area. At camera location three, approximately 1000 feet prior to the accident, the most desirable position for a vehicle was in lane one. Consequently, the right hand wheel should be near the right shoulder.

In order to perform the analysis at camera location one, the vehicles in lane one were grouped into the following four categories: 00, 0, and 1; 2; 3; 4 and 5. These groups are shown along the reference line in Figure 9. Consulting Table 11, it is seen that the lateral placement distribution of test and control vehicles is not significantly different.

A similar analysis on the vehicles in lane two yielded the same result. Only two lane divisions were used in the analysis for lane two. One lane division included section 6; and the other division included sections 7, 8, 9, as seen in Figure 9.

At camera location two the categories used in the analysis were the same as for camera location one. However, the test vehicles had

Table 11. Significant Differences in Lateral Placement Distribution of Test and Control Vehicles

Source of Variation			Levels of Significance	
Experiment	Location	Lane	10%	20%
	1	1	Non-Significant	Non-Significant
1	2	1	Significant	Significant
	3	1	Significant	Significant
	1	1	Significant[1]	Significant[1]
2	2	1	Non-Significant	Non-Significant
	3	1	Non-Significant	Non-Significant
	1	1	Non-Significant	Non-Significant
3	2	1	Non-Significant	Non-Significant
	3	2	Non-Significant	Significant[1]

[1]Favors control group. At these locations the control vehicles were farther away from the median (Experiment 2) or the activity area (Experiment 3) than were the test vehicles.

received the message, "Accident ahead, two miles," which the control vehicles did not receive. Again, consulting Table 11 it is seen that a significant difference in lateral placement between test and control vehicles existed. The test vehicles tended to occupy positions closer to the right hand side of the road than did the control vehicles.

At camera location three the test group of vehicles tended to occupy positions significantly closer to the right hand shoulder than did the control vehicles. This difference is attributed to the message received by the test group prior to the camera location informing them, "Accident ahead, use right lane."

In summary, then, for the accident experiment one can conclude that the messages received by the test group did affect their lateral placement at camera locations two and three to such a degree that it differed significantly from the lateral placement of the control group who did not receive the messages.

Experiment Two

Experiment number two was the grass cutting experiment with mowers operating on the median in the activity area.

Table 11 indicates a significant difference in the lateral placement distribution of test and control vehicles at location one. At this location, the control vehicles occupied a position closer to the right hand shoulder than did the test vehicles. At the other camera locations, no significant differences existed between test and control vehicles. The test vehicles received two messages, one prior to camera location two and one prior to location three. The messages were "Grass cutting, two miles ahead," and, "Grass cutting, slow to 40," respectively.

The results of the contingency tests for experiment two indicate that the messages did not have any significant influence on the lateral placement distribution of test and control vehicles of camera locations two and three. Prior to these camera locations the test vehicle operators had received messages concerning the activity in the activity area.

Experiment Three

In experiment three the State Highway Department of Kentucky had experiment and forces on duty "skin patching" the pavement on the right hand shoulder. This activity caused the right hand, or outside lane, to be blocked. Therefore, in the analysis of lateral placement in this experiment, the most favorable wheel path in the vicinity of the activity area would be as close as possible to the left hand shoulder.

At camera location one the analysis of lateral placement indicated that even at the 20 per cent level in the contingency test there was no significant difference between test and control vehicles in lane one or lane two. This is quite understandable as up to this point no messages were received by the driver of the test vehicles that would cause his lateral placement distribution to be different from that of the control group.

Prior to camera location two the test vehicles received the following message: "Men working, slow to 40." In the activity area a flagman and signs were used. The lateral placement analysis this time considered the vehicle paths in three lane divisions, 4, 5; 6; and 7, as illustrated in Figure 9. The analysis showed that although the test vehicles received messages prior to the zone of activity, their lateral placement distribution from the right hand edge of the pavement was not significantly different from the control group distribution at the 10 per cent level.

In the film analysis of the three experiments a record was kept of the test and control vehicle activity in the zone from the transmitter to the grid section of the camera field of view. Passing, weaving and lane changes of the test and control vehicles were the activities recorded.

The results indicated that at camera locations one, two and three, for all experiments the behavior of the test and control vehicles was essentially similar. At the first camera location no difference was expected. The message received just prior to the second camera location did not request any lane maneuvering and consequently no difference was expected. At the third camera location the number of lane changes by the test group was 42 out of 106 test vehicles appearing in the film. For the control vehicles, 45 out of 108 vehicles made a lane change.

Interview Data Analysis

All vehicles designated as test vehicles were required to stop at the interview area and the drivers were interviewed. The interview area was located approximately one mile beyond the last transmitter. Four warning signs prior to the interview area and the last transmitter message helped to provide a smooth traffic operation in the interview area. At the interview area a State Trooper was available to direct traffic should any congestion develop and to aid in the recovery of test radios on vehicles should they fail to stop at the interview area.

During the eight days in which the tests were conducted, a total of 1616 interviews were secured. Of these, however, 228 were invalidated for various reasons. Figure 11 shows graphically the reasons for rejecting certain interviews. A person who was more familiar with the project than an ordinary motorist was classed as a biased person. Such people were Highway Department personnel or interested observers from Delco, and so forth. These people were not interviewed.

Indicated in Figure 11 the most common reason for rejecting an interview was equipment malfunction. The receivers occasionally failed and so the test vehicles proceeded through the test section perhaps receiving some or none of the messages. This problem was especially

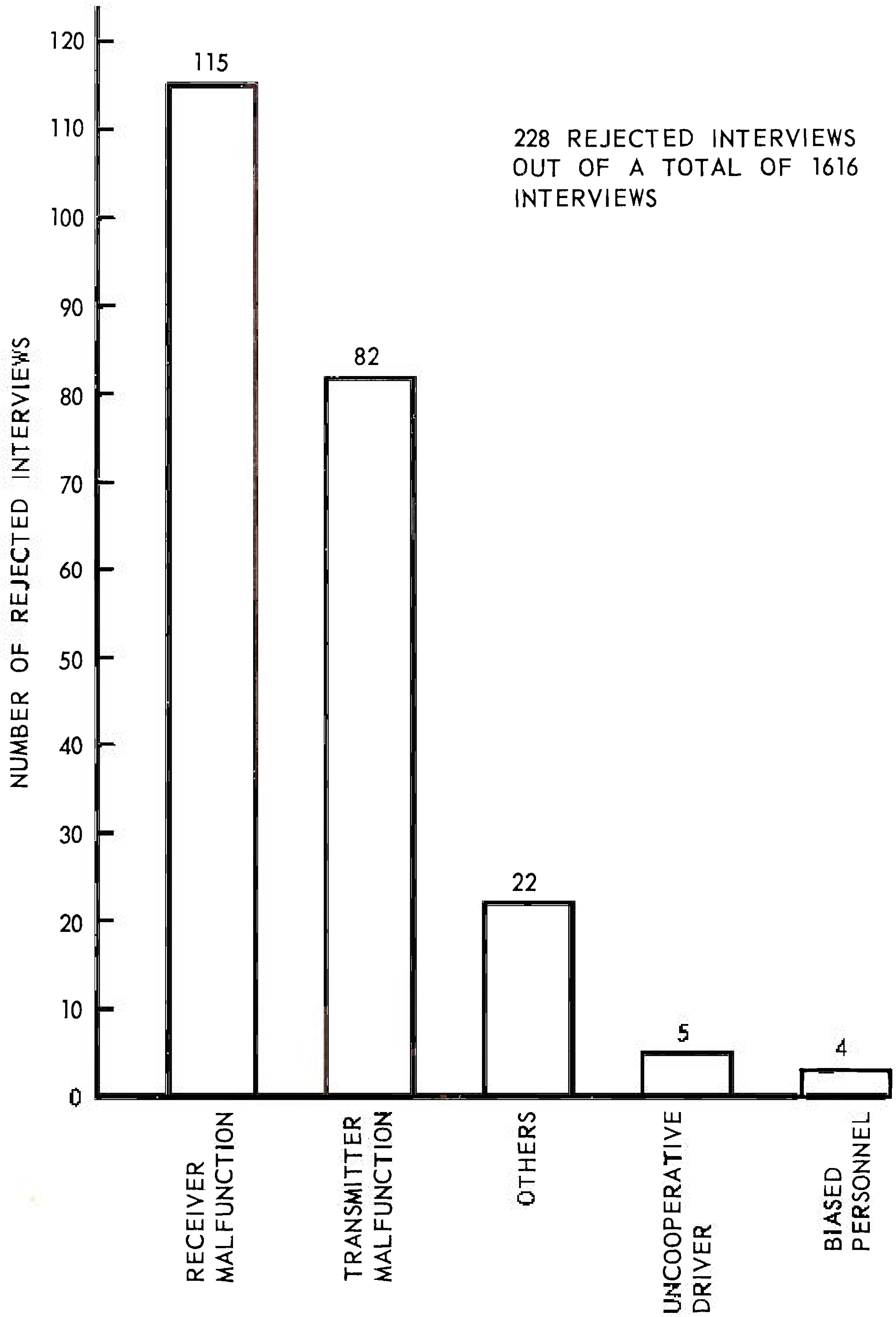


Figure 11. Number and Causes of Rejected Interviews.

evident with large trucks, who many times heard only static. Another reason for interview rejection was malfunction of the transmitting equipment. In this case, the message repeater usually was the cause of the trouble. When a transmitter breakdown occurred, the test vehicles would receive an unclear message or no message at all at that location. The seriousness of the situation depended upon which particular transmitter broke down. The equipment malfunctions were unquestionable a flaw in the experiments that allowed some bias to enter into even the objective film analysis, because it was impossible to determine whether the test car appearing on the film had or had not received a message.

Of the interviews obtained on each day of the project, slightly more than half were classified as having a non-local destination which reflects the recreational and other long distant traffic present on the toll road. The Kentucky Toll Road is one of the main routes out of Louisville toward the lake districts in southern Kentucky.

The traffic was predominantly composed of passenger vehicles, but the truck percentage on Tuesdays, Wednesdays and Thursdays represented approximately 30 per cent of the volume.

The male-female ratio of drivers in the test group was very large. Of the 1388 acceptable interviews taken, 1136 were males and only 252 females.

On the last day of testing, during the second part of the route information experiment, the interviewed drivers were asked the purpose of their trip. The results of this question illustrate the occurrence of a large percentage of recreational type traffic and is especially evident in the non-local destination traffic.

In response to the question concerning the ability of the messages to be understood by the test vehicle operators, the respondents generally indicated that the messages were well within the limits required for adequate comprehension as over 95 per cent of the drivers in every experiment thought the messages in general were of adequate quality.

Of those drivers who had difficulty in understanding one or all of the messages, most of them indicated that when a message was received it was unintelligible or garbled. This situation reflects the malfunction of the receivers or transmitters that was present during some of the tests. Other reasons given were insufficient number of repetitions of the messages and insufficient information contained in the messages.

The majority of the drivers indicated that the messages they received did aid them in some way. Results showed that for experiments one, two and three, the radio messages did make the drivers feel safer and more alert while at the same time contributing to a smoother operation of their vehicle. There were some drivers, however, who felt that the messages were of no help to them while driving over the test section. Message clarity, annoyance and the opinion that messages were not needed formed the majority of the dissensions.

The opinion of 90 per cent of the respondents was that the joint use of radio and signs was better than just signs alone and also that the use of radio communications would be very advantageous in places where presently no signs are normally used. The latter situations arise principally at accident scenes and perhaps at some maintenance areas.

Some drivers considered the use of radio communications an advantage in that messages could be kept up-to-date as contrasted to some types of signing.

Over 95 per cent of the drivers agreed that the use of roadside radio communications would certainly be an advantage during inclement weather conditions. Other uses indicated a variety of applications.

The possibility of using radio communications to inform drivers of scenic and historic locations as well as service areas was accepted very well and little difference found between the responses given local and non-local drivers. Approximately 70 per cent of all drivers were of the opinion that the information on scenic and historic information would be useful, while over 80 per cent were receptive to the idea of receiving information about service areas. Perhaps some of the attractiveness of this information service could be attributed to the large percentage of recreational type traffic at this time of the year.

Over 95 per cent of the respondents thought that the system would be of help in the vicinity of complex interchanges. Similar reception was accorded the use of radio communications to warn of detours and traffic congested areas. Many other possible uses were given.

The opinion that a radio communication system should be incorporated into all of the major highways in the nation was almost unanimous.

In order to properly formulate the question of willingness to pay it was necessary to determine first if the vehicle was equipped with a radio. Approximately 15 per cent of the vehicles interviewed did not have radios. Included in this figure are all the commercial trucks that ordinarily do not have a radio.

To evaluate the driver acceptability of the radio communications system, the last question asked was how much the driver would be willing to pay above the cost of his car radio for an installation of this radio equipment with the assumption that this installation would work automatically whether his radio was on or off and could be used on all of the major state highways.

The replies to this question were summarized in various groupings, according to sex and destination of trip, i.e. local or non-local. After tabulation, analysis showed that no significant differences were evident between the amount the male and female or the local and non-local drivers were willing to pay.

Figure 12 presents the cost results according to experiment summed over all drivers. Over 75 per cent of drivers in all four experiments were willing to invest at least fifteen to thirty dollars in the system. Considering all four experiments together, approximately 48 per cent were willing to pay in excess of thirty dollars, while 25 per cent were willing to pay over fifty dollars for the system. The amounts over fifty dollars varied up to two hundred dollars but for statistical analysis a mean value of seventy-five dollars was used.

Considering all the experiments approximately eight per cent of the drivers indicated that they would not purchase such an installation. It is interesting to note that in experiments one, two and three, there were only about six per cent who would not purchase the system, while in experiment four, the route information experiment, 11 per cent indicated they were unwilling to purchase the system.

The interview data indicated that the test vehicle operators considered this communication system as a definite possibility in a larger

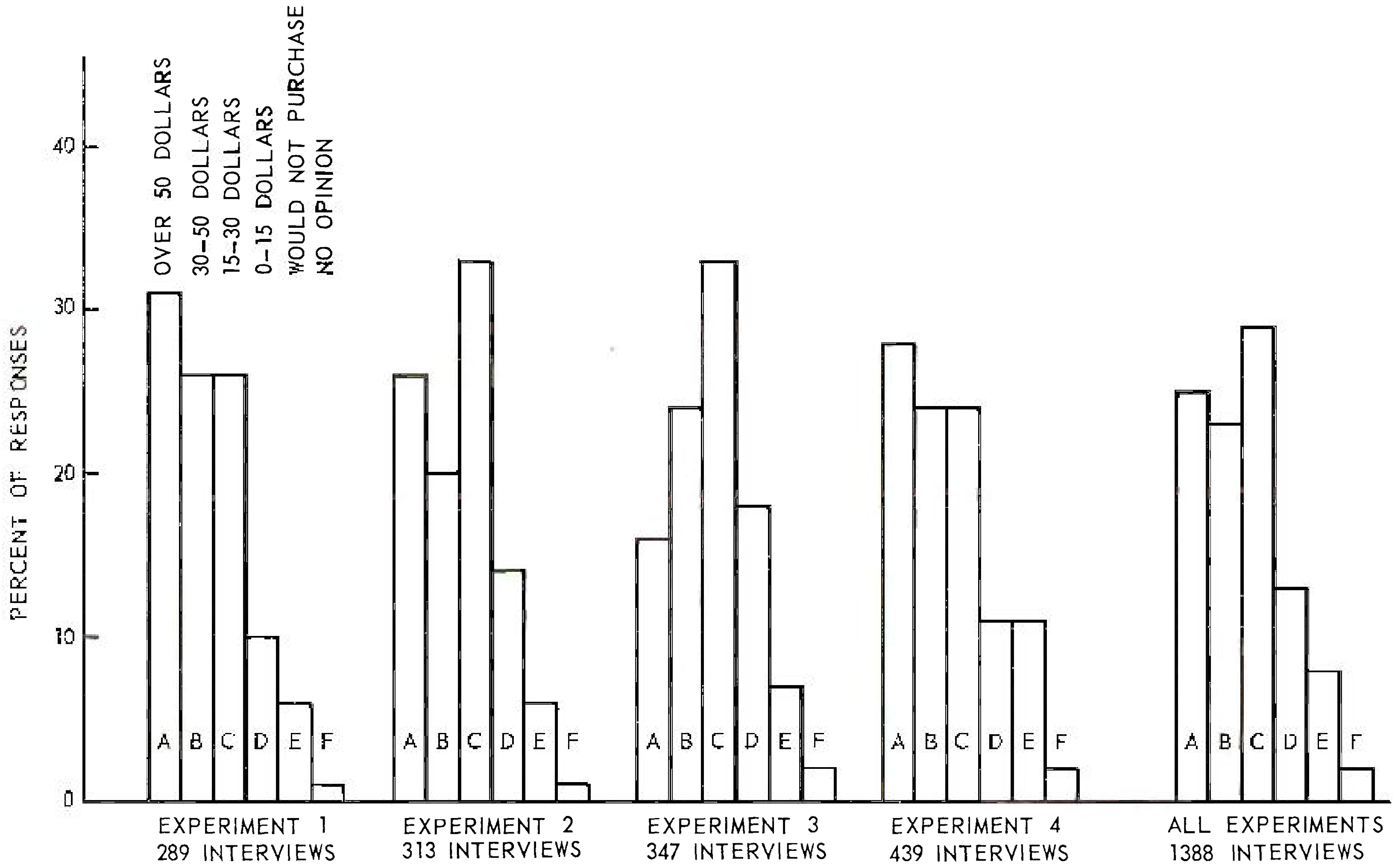


Figure 12. Amount Drivers Were Willing to Pay Above the Cost of a Car Radio to Secure a Radio System Comparable to the Test Radio.

system designed to inform and control drivers. The drivers indicated the degree of their acceptance by specifying the maximum amount they would be willing to invest to obtain such a system, given that they would be able to use it on most of the major state routes where conditions warranted it and that the radio would be part of a conventional car radio.

CHAPTER V

RESULTS, CONCLUSIONS AND RECOMMENDATIONS

Summary of Results

A summary of the results of the analysis of data collected on this study can be outlined as follows:

1. In the first three experiments, the analysis of the data using analysis of variance and multiple range tests indicated no significant differences in the speeds of the test and control vehicles at camera location one. No information was transmitted immediately in advance of camera location one.

2. In the first three experiments a significant difference between speeds of test and control vehicles did exist at camera location two where the transmitted message in advance of the camera location was advisory only.

3. In the first three experiments a significant difference between speeds of test and control vehicles existed at camera location three, where the transmitted message in advance of the camera location was both advisory and directive.

4. In experiment one, significant differences in the lateral placement distribution of test versus control vehicles occurred at camera locations two and three but not at camera location one.

5. In experiment two, significant differences in the lateral placement distribution of test versus control vehicles occurred only at camera location one. At camera location one, the control vehicles

occupied positions significantly closer to the right hand shoulder than did the test vehicles.

6. In experiment three, significant differences in the lateral placement distribution of test versus control vehicles occurred only at camera location three, but the significance was at the 20 per cent level and favored the control vehicles.

7. Of the 1616 interviews, 228 were considered biased and rejected. Of the 228 rejected interviews, equipment malfunction accounted for 197.

8. Ninety per cent of the unbiased interviews indicated the messages were adequately or easily understood.

9. Most of the difficulty associated with understanding the messages was caused by messages that were not clear or garbled in reception.

10. Messages received did help in making the test vehicle operators feel safer, more alert, and contributed to a smoother operation of the vehicle through the test section.

11. Almost every interviewed driver thought that roadside radio communications in addition to standard signs were better than just signs alone in most situations where it was necessary to give information or to caution drivers. The respondents also indicated that radio communication could be used very effectively in particular situations where ordinarily no signing is used, such as in the vicinity of an accident.

12. It was almost the unanimous opinion of the interviewed drivers that roadside radio communication is a useful device in aiding the driver during inclement weather conditions.

13. A large percentage of the drivers favored the use of roadside

radio communications in the vicinity of complex interchanges, traffic congested areas and detours. The use of the radio system to give information related to scenic and historic areas as well as service areas was acceptable to about 70 per cent of the drivers.

14. Most drivers would like to see this roadside radio communications system used on all major state highways.

15. In response to the cost question, over 25 per cent of the operators were willing to pay in excess of fifty dollars for an installation. Of the operators, 48 per cent indicated that they would be willing to invest over thirty dollars for an installation. Only 8 per cent of those vehicle operators interviewed indicated that they would not purchase such a system. In analyzing the willingness-to-pay for the various groupings of the data, no significant difference existed in the amount that males compared to females were willing to pay. This was also true with respect to local and non-local destination drivers.

Conclusions

An evaluation of the results of the analysis of data indicated the following conclusions.

1. The speed of a test vehicle was not significantly affected by the presence of the test radio equipment mounted on the vehicle.

2. The messages received by the test vehicle operators did have a significant effect upon the speed of their vehicles when compared to the speed of control vehicles who did not receive the messages, but were nevertheless, cognizant of the experiments being conducted.

3. In general, the messages received by the test vehicle operators did not always cause them to operate their vehicles in a manner such

that the lateral placement distribution of the test vehicles differed significantly from the lateral placement distribution of the control vehicles, whose operators did not receive the messages.

4. The results of the personal interviews conducted with the test vehicle operators yielded several conclusions:

(a) The test group, in general, accorded the roadside radio communication system a favorable reception.

(b) They agreed that the system did help them while driving over the test section, that the system could give desirable and necessary information concerning a variety of conditions that exist on the highways, and that the radio system could supplement the signs in some cases and provide acceptable service in other cases where signs are not used.

(c) The radio system, even though in experimental stages of development, did not create noticeable annoyance to the driver.

5. Based upon the results of the willingness-to-pay question, the driver acceptance for this system was considered good. Recognizing the limitations of the data collected, the author can conclude that if the roadside radio communications system did become a reality, and that its performance was at least comparable to the equipment tested, then, at least half of the motoring public with similar driving habits as those in the experiment, would be willing to pay at least thirty dollars for an installation.

Recommendations

The following recommendations are made concerning this study of roadside radio communication:

1. Additional research should be conducted to investigate the effect of radio communications on repeat traffic in an urban area. Also, research must be conducted into the number of transmitters needed to provide an effective radio communications service for a typical freeway. Consideration must also be given to the development of a central control system for the transmitters.

2. Modification of the existing message repeater should be considered in order to eliminate the mechanical and electrical noises associated with the magnetic drum repeater assembly.

3. Experiments with the equipment should be undertaken in order to determine the field characteristics of the induction loop and the associated implications on the operation of the receivers.

A P P E N D I X

APPENDIX

INFORMATION GIVEN TO "TEST" VEHICLE OPERATORS AT TOLL PLAZA AREA

(To be Explained by Toll Plaza Personnel)

The Georgia Institute of Technology and the Federal Bureau of Public Roads is conducting research on the use of radio in traffic control and driver information. You have been selected to participate in an experiment that is designed to evaluate the effectiveness of this type of communication in giving you advance warning of road conditions.

Are you willing to cooperate in this experiment?

You can aid us in this work by accepting this receiver which will broadcast messages to you as you drive along this road for the next 10 miles. These messages will inform you about actual road conditions.

The last message broadcast to you will inform you of the drop-off point for the receivers. It is most important that the receiver be returned. At this point you will be asked several short questions about your experience with the test radio.

We would like to put markers on your car. These markers are designed to come off very easily and will not leave any residue. We shall remove them at the end of the test. The markers will identify your car as a test vehicle. The receiver we give you will not harm your car as it has protective covering on contact points.

We would also appreciate it if you would turn off your radio during the test so that you may hear the messages better. In the future this receiver can be made a part of your radio, and will operate whether your radio is on or off.

Thank you for your cooperation.

Information Given to Control Vehicle Operators at Toll Plaza

The Georgia Institute of Technology and the Federal Bureau of Public Roads are conducting research on the use of radio in traffic control and driver information. You have been selected to participate in an experiment that is designed to evaluate the effectiveness of this type of communication in giving you advance warning of road conditions.

Are you willing to cooperate in this experiment?

You can aid us in this work by participating as part of the control group for the experiment. Other people in the experiment group will receive test radios.

We would like to attach a sticker to your car that will identify your car as the control vehicle. Our test section is about 10 miles long and you may remove the sticker at your first opportunity after you pass through this section. You can take this sticker off by pulling very gently and it will leave no residue.

Thank you for your cooperation.

QUESTIONS FOR INTERVIEW
QUESTIONNAIRE USED AT END OF TEST SECTION

Introduction

An interviewer, pleasant in appearance and personality, approaches the automobile and notes the first entries on his recording sheet:

Make and Year of Car
License Number and State
Sex and Approximate Age of Driver

Then he says:

"Good afternoon, Sir. We are conducting a survey of driver opinions on the use of radio control for traffic control and driver information. Would you be so kind as to answer a few questions for us based on your short experience with the radio receiver units?"

1. What is the destination of your trip?

2. Have you participated in this experiment before (in control group or with receiver):

    (a) Yes

    (b) No

(Change order of asking questions)

3. Were the messages in general:

    (a) Adequately Understood

    (b) Easy to Understand

    (c) Difficult to Understand

NOTE: IF (c) IS MARKED, ASK QUESTION 4, OTHERWISE GO TO QUESTION 5.

(Change order of asking questions)

4. If the messages were difficult to understand, what was the main reason:

    (a) Radio loud enough

    (b) Message garbled

    (c) Messages repeated enough times

(d) Insufficient information

(e) Lack of warning of impending message

(f) Other ( )

(Change order of asking questions)

5. Did the messages help you in driving:

   (a) Felt safer

   (b) Increased awareness

   (c) Smoother traffic operation

   (d) Other ( )

(Change order of asking questions)

6. If the messages were not any help in your driving, what were the reasons:

   (a) Message clarity Yes; No; No Opinion

   (b) Annoyed by radio Yes; No; No Opinion

   (c) Messages needed to clearly understand traffic situation

   (d) Other ( )

7. In comparing the use of radio messages and roads with road signs alone, do you think that radio and road signs are:

   (a) Better
   (b) The same
   (c) Worse

   than road signs alone?

(Change order of asking questions)

8. Ordinarily many situations like accidents and some maintenance activities are not signed, do you think that radio would be

   (a) Better
   (b) The same
   (c) Worse

   in this situation?

(Change order of asking questions

9. Do you think this system would facilitate driving under any of the following conditions:

(a)	Night	Yes;	No;	No Opinion
(b)	Fog	"	"	"
(c)	Snow	"	"	"
(d)	Rain	"	"	"
(e)	Other ( )			

(Change order of asking questions)

10. Would you like to see this system used for:

(a)	Complex interchanges	Yes;	No;	No Opinion
(b)	Scenic or historic locations	"	"	"
(c)	Service area notices	"	"	"
(d)	Detour instructions	"	"	"
(e)	Traffic congestion announcements	"	"	"
(f)	Other ( )			

11. Would you like to see this system put into future use on all major highways:

(a) Yes

(b) No

12. Do you have a radio in your car:

(a) Yes

(b) No

NOTE: INTERVIEWER SHOULD NOT HAVE TO ASK THIS QUESTION BUT SHOULD USE HIS POWER OF OBSERVATION.

13. This receiver can be made a part of a car radio, and will operate whether the radio is on or off. What is the additional highest price you would be willing to pay above the regular price of a car radio, if all important state highways in the United States had this service:

(a) Would not purchase

(b) Over $50.00

(c) $30.00 to $50.00

(d) $15.00 to $30.00

(e) $0.00 to $15.00

14. Remarks: Place pertinent information which may have created bias in the interview in the space provided.

INTERVIEW FORM

INTERVIEW NUMBER	DATE	INTERVIEWER
____________	____________	____________

		AGE:	MALE	(11)	FEMALE	(12)
TYPE OF VEHICLE ______	(5-6)	UNDER 25	____	1	____	1
YEAR OF VEHICLE ______	(7-8)	26 - 35	____	2	____	2
LICENSE NUMBER ______		36 - 45	____	3	____	3
STATE ______		OVER 45	____	4	____	4

1. DESTINATION: LOCAL ______ 1 OUT OF STATE ______ 2 (13)

2. PARTICIPATE IN EXPERIMENT BEFORE: YES ____ 1 NO ____ 2 (14)

3. MESSAGES:

ADEQUATELY UNDERSTOOD.........	______	1	
EASY TO UNDERSTAND............	______	2	(15)
DIFFICULT TO UNDERSTAND.......	______	3	

4. MESSAGES DIFFICULT:

	YES		NO		NO OPINION		
RADIO LOUD ENOUGH.............	______	1	______	2	______	3	(16)
MESSAGE GARBLED...............	______		______		______		(17)
MESSAGE REPEATED..............	______		______		______		(18)
INSUFFICIENT INFORMATION......	______		______		______		(19)
LACK WARNING..................	______		______		______		(20)
OTHER.........................	______		______		______		(21)

5. MESSAGES HELP IN DRIVING:

FELT SAFER....................	______	______	______	(22)
INCREASED AWARENESS...........	______	______	______	(23)
SMOOTHER OPERATION............	______	______	______	(24)
OTHER ( ).............	______	______	______	(25)

6. MESSAGES NO HELP:

CLARITY.......................	______	______	______	(26)
ANNOYED BY RADIO..............	______	______	______	(27)
MESSAGES NEEDED...............	______	______	______	(28)
OTHER ( ).............	______	______	______	(29)

7. COMPARISON WITH SIGNS:

BETTER......	____	1	
SAME........	____	2	(30)
WORSE.......	____	3	

8. COMPARISON WITH NO SIGNS:

BETTER......	____	1	
SAME........	____	2	(31)
WORSE.......	____	3	

9. FACILITATE DRIVING IN:

	YES	NO	NO OPINION	
NIGHT............................	____ 1	____ 2	____ 3	(32)
FOG..............................	____	____	____	(33)
SNOW.............................	____	____	____	(34)
RAIN.............................	____	____	____	(35)
OTHER ( )................	____	____	____	(36)

10. SYSTEM USED FOR

	YES	NO	NO OPINION	
COMPLEX INTERCHANGES.............	____	____	____	(37)
SCENIC OR HISTORIC INFORMATION...	____	____	____	(38)
SERVICE AREA.....................	____	____	____	(39)
DETOUR...........................	____	____	____	(40)
TRAFFIC CONGESTION...............	____	____	____	(41)
OTHER ( )................	____	____	____	(42)

11. GENERAL USE IN MAJOR HIGHWAYS:	____	____	____	(43)
12. CAR RADIO:	____	____		(44)
13. ADDITIONAL COST: WOULD NOT PURCHASE (DOLLARS)	____	____	____	(45)

14. REMARKS: ____

____

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